CLAIMS

1. An optical heterostructure comprising:

a matrix having an index of refraction;

a first bandgap region defined in said matrix; and

a second bandgap region defined in said matrix, wherein

said second bandgap region is characterized by a periodic arrangement of inclusions in said matrix,

said inclusions have an index of refraction substantially different than said index of refraction of said matrix,

said first and second bandgap regions alternate in succession along a primary dimension of optical propagation of said heterostructure device to define a succession including at least one bandgap region of said first type interposed between a pair of bandgap regions of said second type,

said first bandgap region defines a first optical bandgap of said optical heterostructure,

said second bandgap region defines a second optical bandgap of said optical heterostructure,

a spacing between said band gap regions of said second type created by said interposition of said first band gap region there between is such that said first optical bandgap is centered at a different wavelength than said second optical bandgap and such that a transmission bandwidth is defined between said first and second optical bandgaps.

2. An optical heterostructure comprising:

a matrix having an index of refraction;

a first bandgap region defined in said matrix; and

a second bandgap region defined in said matrix, wherein

said first and second bandgap regions alternate in succession along a primary dimension of optical propagation of said heterostructure device,

said first bandgap region is characterized by a periodic arrangement of first inclusions in said matrix,

said periodic arrangement of said first inclusions in said matrix define a first optical bandgap of said optical heterostructure,

said second bandgap region is characterized by a periodic arrangement of second inclusions in said matrix,

said periodic arrangement of said second inclusions in said matrix define a second optical bandgap of said optical heterostructure,

said first and second inclusions have an index of refraction substantially different than said index of refraction of said matrix,

said first optical bandgap is centered at a different wavelength than said second optical bandgap, and

a transmission bandwidth is defined between said first and second optical bandgaps.

3. An optical heterostructure as claimed in claim 2 wherein said first and second inclusions have substantially identical indices of refraction.

4. An optical heterostructure as claimed in claim 2 wherein said matrix has a relatively high index of refraction and said first and second inclusions have a relatively low index of refraction.

5. An optical heterostructure as claimed in claim 2 wherein said matrix has a relatively low index of refraction and said first and second inclusions have a relatively high index of refraction.

6. An optical heterostructure as claimed in claim 2 wherein said first and second bandgap regions alternate along a primary dimension of optical propagation of said heterostructure device to define a plurality of first bandgap regions and a plurality of second bandgap regions.

7. An optical heterostructure as claimed in claim 6 wherein said first and second bandgap regions further alternate along a dimension orthogonal to said primary dimension of optical propagation of said heterostructure device.

8. An optical heterostructure as claimed in claim 2 wherein:

said optical heterostructure further comprises at least one additional bandgap region defined in said matrix;

said additional bandgap region is characterized by a periodic arrangement of additional inclusions in said matrix,

said periodic arrangement of said additional inclusions in said matrix define at least one additional optical bandgap of said optical heterostructure,

said additional inclusions have an index of refraction substantially different than said index of refraction of said matrix,

said additional optical bandgap is centered at a different wavelength than said first and second optical bandgaps.

9. An optical heterostructure as claimed in claim 8 wherein said first, second, and additional bandgap regions alternate along a primary dimension of optical propagation of said heterostructure device to define a plurality of first bandgap regions, a plurality of second bandgap regions, and a plurality of additional bandgap regions.

10. An optical heterostructure as claimed in claim 9 wherein said first, second, and additional bandgap regions further alternate along a dimension orthogonal to said primary dimension of optical propagation of said heterostructure device.

11. An optical heterostructure as claimed in claim 2 wherein said wavelength difference in said first and second optical bandgaps is attributable to a difference in respective geometries of said first and second inclusions, respective sizes of said first and second inclusions, respective periodicities of said first and second inclusions, respective compositions of said first and second inclusions, and combinations thereof.

12. An optical heterostructure as claimed in claim 2 wherein each of said first inclusions approximate a geometrical shape that is substantially the same as a geometrical shape approximated by each of said second inclusions.

13. An optical heterostructure as claimed in claim 2 wherein each of said first inclusions approximate a geometrical shape that is substantially different than a geometrical shape approximated by each of said second inclusions.

14. An optical heterostructure as claimed in claim 2 wherein each of said first and second inclusions approximate one or more of a variety of geometrical shapes.

15. An optical heterostructure as claimed in claim 2 wherein a cross-sectional area of a geometrical shape approximated by said first inclusions is substantially different than a cross-sectional area of a geometrical shape approximated by said second inclusions.

16. An optical heterostructure as claimed in claim 15 wherein said geometrical shape approximated by said first inclusions is substantially the same as said geometrical shape approximated by each of said second inclusions.

17. An optical heterostructure as claimed in claim 2 wherein a volume of a geometrical shape approximated by said first inclusions is substantially different than a volume of a geometrical shape approximated by said second inclusions.

18. An optical heterostructure as claimed in claim 17 wherein said geometrical shape approximated by said first inclusions is substantially the same as said geometrical shape approximated by each of said second inclusions.

19. An optical heterostructure as claimed in claim 2 wherein a periodicity approximated by said first inclusions is substantially different than a periodicity approximated by said second inclusions.

20. An optical heterostructure as claimed in claim 19 wherein said geometrical shape approximated by said first inclusions is substantially the same as said geometrical shape approximated by each of said second inclusions.

21. An optical heterostructure as claimed in claim 2 wherein said matrix defines a substantially homogenous composition throughout said optical heterostructure.

22. An optical heterostructure as claimed in claim 2 wherein said matrix has a substantially heterogeneous composition throughout said optical heterostructure.

23. An optical heterostructure as claimed in claim 22 wherein said substantially heterogeneous composition has a spatially variant index of refraction.

24. An optical heterostructure as claimed in claim 22 wherein said substantially heterogeneous composition defines a spatially variant composition.

25. An optical heterostructure as claimed in claim 2 wherein said matrix comprises a material selected from Si, In, Ga, Al, Sb, As, Ge, P, N, O, $BaTiO_3$, lithium niobate, GaAs, InP, InGaAsP, a semiconductor, a chalcogenide, a polymer, an organic material, air, and combinations thereof.

26. An optical heterostructure as claimed in claim 2 wherein said matrix comprises a dopant.

27. An optical heterostructure as claimed in claim 26 wherein said dopant comprises an optically active material.

28. An optical heterostructure as claimed in claim 26 wherein said dopant comprises a rare earth element.

29. An optical heterostructure as claimed in claim 26 wherein said dopant comprises erbium.

30. An optical heterostructure as claimed in claim 2 wherein said first and second inclusions comprise a material selected from air, an inert gas, silica, a polymer, an aqueous material, and combinations thereof.

31. An optical heterostructure comprising first and second optical bandgap regions, wherein:

said first bandgap region comprises an optical medium having a relatively high index of refraction and an optical medium having a relatively low index of refraction;

said second bandgap region comprises an optical medium having a relatively high index of refraction and an optical medium having a relatively low index of refraction;

said high index optical medium and said low index optical medium of said first bandgap region are arranged in a periodic lattice and define a first optical bandgap;

said high index optical medium and said low index optical medium of said second bandgap region are arranged in a periodic lattice and define a second optical bandgap; and

said first bandgap is centered at a shorter wavelength than said second bandgap.

32. An optical heterostructure as claimed in claim 31 wherein said first bandgap is narrower than said second bandgap.

33. An optical waveguide comprising a core region and a boundary region having substantially different indices of refraction, wherein:

said core region defines a primary dimension of optical propagation and is bounded by said boundary region at least along said primary dimension of optical propagation; and

said core region defines a heterostructure region comprising

a matrix having an index of refraction,

a first bandgap region defined in said matrix, and

a second bandgap region defined in said matrix, wherein

said first bandgap region is characterized by a periodic arrangement of first inclusions in said matrix,

said periodic arrangement of said first inclusions in said matrix define a first optical bandgap of said optical heterostructure,

said second bandgap region is characterized by a periodic arrangement of second inclusions in said matrix,

said first and second inclusions have an index of refraction substantially different than said index of refraction of said matrix,

said periodic arrangement of said second inclusions in said matrix define a second optical bandgap of said optical heterostructure,

said first optical bandgap is centered at a different wavelength than said second optical bandgap, and

a transmission bandwidth is defined between said first and second optical bandgaps.

34. An optical waveguide as claimed in claim 33 wherein said core region has a relatively high index of refraction and said boundary region has a relatively low index of refraction.

35. An optical waveguide as claimed in claim 33 wherein said core region has a relatively low index of refraction and said boundary region has a relatively high index of refraction.

36. An optical waveguide as claimed in claim 33 wherein said matrix comprises an optically functional material and exhibits a substantial change in refractive index in response to a refractive index control parameter.

37. An optical waveguide as claimed in claim 36 wherein said optically functional material comprises a non-linear photonic material, an electrooptic material, a thermo-optic material, a semiconductor, and combinations thereof.

38. An optical waveguide as claimed in claim 36 wherein said control parameter comprises intensity of an optical signal propagating along said primary dimension of optical propagation, intensity and distribution of an electric field across said matrix, a temperature of said heterostructure, a free carrier concentration in said matrix, and combinations thereof.

39. An optical waveguide as claimed in claim 33 wherein said first and second inclusions comprise an optically functional material and exhibit a substantial change in refractive index in response to a refractive index control parameter.

40. An optical waveguide as claimed in claim 33 wherein said matrix and said first and second inclusions comprise an optically functional material and exhibit a substantial change in refractive index in response to a refractive index control parameter.

41. An optical waveguide as claimed in claim 33 wherein said boundary region comprises air, silicon dioxide, a material characterized by an index of refraction approximating that of air or silicon dioxide, or combinations thereof.

42. An optical waveguide as claimed in claim 33 wherein said boundary region comprises a combination of spatially distinct regions.

43. An optical waveguide as claimed in claim 33 wherein said boundary region comprises a region of air and a spatially distinct region of silicon dioxide.

44. An optical waveguide comprising a core region and a boundary region having substantially different indices of refraction, wherein:

said core region defines a primary dimension of optical propagation and is bounded by said boundary region at least along said primary dimension of optical propagation; and

said core region defines a heterostructure region, wherein

said heterostructure region comprises first and second bandgap regions,

said first bandgap region comprises an optical medium having a relatively high index of refraction and an optical medium having a relatively low index of refraction,

said second bandgap region comprises an optical medium having a relatively high index of refraction and an optical medium having a relatively low index of refraction,

said high index optical medium and said low index optical medium of said first bandgap region are arranged in a periodic lattice and define a first optical bandgap,

said high index optical medium and said low index optical medium of said second bandgap region are arranged in a periodic lattice and define a second optical bandgap,

said first bandgap is narrower than said second bandgap and is centered at a shorter wavelength than said second bandgap, and

a transmission bandwidth is defined between said first and second optical bandgaps.

45. An optical waveguide as claimed in claim 44 wherein said first and second bandgap regions alternate along said primary dimension of optical propagation to define a plurality of first bandgap regions and a plurality of second bandgap regions.

46. An optical device comprising components configured to function as one of an optical isolator, circulator, multiplexer, demultiplexer, wavelength locker, modulator, variable attenuator, dispersion compensator, power monitor, laser, amplifier, detector, router, switch,

interleaver, and combinations thereof, wherein said optical device employs at least one optical heterostructure comprising:

a matrix having an index of refraction,

a first bandgap region defined in said matrix, and

a second bandgap region defined in said matrix, wherein

said first bandgap region is characterized by a periodic arrangement of first inclusions in said matrix,

said periodic arrangement of said first inclusions in said matrix define a first optical bandgap of said optical heterostructure,

said second bandgap region is characterized by a periodic arrangement of second inclusions in said matrix,

said first and second inclusions have an index of refraction substantially different than said index of refraction of said matrix,

said periodic arrangement of said second inclusions in said matrix has a second optical bandgap of said optical heterostructure,

said first optical bandgap is centered at a different wavelength than said second optical bandgap, and

a transmission bandwidth is defined between said first and second optical bandgaps.

50. A method of fabricating an optical heterostructure comprising:

defining a periodic arrangement of first inclusions;

defining a periodic arrangement of second inclusions;

forming said periodic arrangement of first inclusions in a matrix so as to define a first bandgap region in said matrix, wherein

said first inclusions are defined as a material having an index of refraction substantially different than an index of refraction of said matrix, and

said first bandgap region defines a first optical bandgap of said optical heterostructure;

forming said periodic arrangement of second inclusions in said matrix so as to define a second bandgap region in said matrix, wherein

said second inclusions are defined as a material having an index of refraction substantially different than an index of refraction of said matrix,

said second bandgap region defines a second optical bandgap of said optical heterostructure,

said first optical bandgap is centered at a different wavelength than said second optical bandgap, and

a transmission bandwidth is defined between said first and second optical bandgaps.

51. A method of fabricating an optical heterostructure as claimed in claim 50 wherein said respective periodic arrangements of said first and second inclusions are defined in an image transfer mask.

52. A method of fabricating an optical heterostructure as claimed in claim 51 wherein said respective periodic arrangements of said first and second inclusions are defined in an image transfer mask through electron beam lithography.

53. A method of fabricating an optical heterostructure as claimed in claim 50 wherein said respective periodic arrangements of said first and second inclusions are formed by transferring an image from an image transfer mask to said matrix.

54. A method of fabricating an optical heterostructure as claimed in claim 53 wherein said respective periodic arrangements of said first and second inclusions are formed through reactive ion etching.

55. A method of fabricating an optical heterostructure as claimed in claim 50 wherein said periodic arrangements of said first and second inclusions are formed so as to alternate along a

primary dimension of optical propagation of said heterostructure device to define a plurality of first bandgap regions and a plurality of second bandgap regions.

56. A method of fabricating an optical heterostructure as claimed in claim 55 wherein said inclusions are formed such that said first and second bandgap regions further alternate along a dimension orthogonal to said primary dimension of optical propagation of said heterostructure device.

57. A method of fabricating an optical heterostructure as claimed in claim 50 wherein said method further comprises doping said matrix with an optically active material.